



Seasonal-to-decadal climate Prediction for the
improvement of European Climate Services



VOLCADEC

Implementation of a 4D stratospheric aerosol forcing in EC-Earth

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M. Acosta, D. Manubens, P. Echevaria, ...

EC-Earth meeting, January 2018



**Barcelona
Supercomputing
Center**

Centro Nacional de Supercomputación



CMIP5 versus CMIP6



CMIP5 dataset

-> GISS dataset; Sato et al., 1993, updated until 2012:

<http://www.columbia.edu/~mhs119/StratAer/>

-> Q_{ext} at 550nm = $f(\text{latitude, time})$, ω and g prescribed

-> Spectral and vertical distribution homogeneously and constantly distributed

CMIP5 versus CMIP6

CMIP5 dataset

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-> Spectral and vertical distribution homogeneously and constantly distributed

CMIP6 dataset

-> Q_{ext} , ω and $g = f(\text{lat, lev, } \lambda, \text{time})$

-> provided for each model, following its spectral resolution (B. Luo)

-> ftp://iacftp.ethz.ch/pub_read/luo/CMIP6/EC_EARTH/

CMIP6 Implementation



“Simple” scheme

Vertical integration of
Qext at 550 nm (CMIP5
strategy)

(C. Roberts, ECMWF
and M. Ménégóz)

CMIP6 Implementation



“Simple” scheme

Vertical integration of
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“Full” scheme

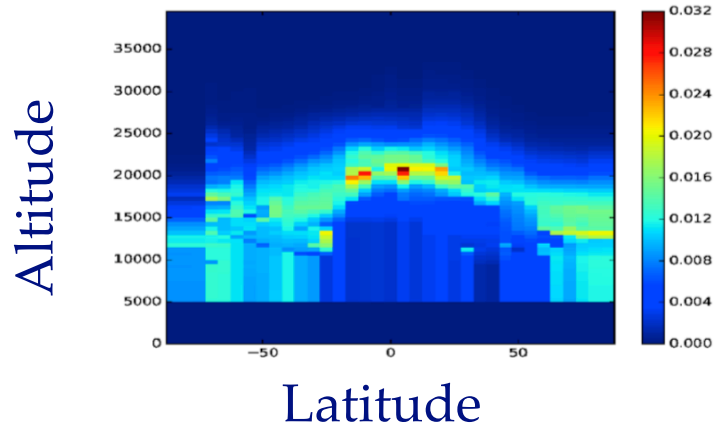
Vertical interpolation
(Off-line, IFS levels)

IFS developments (**completed**)

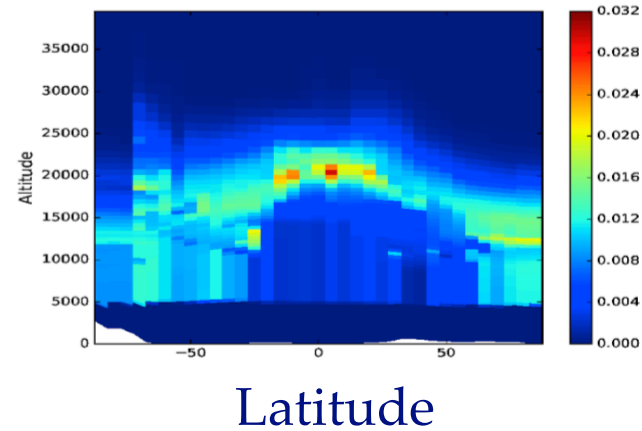
- > Reading the forcing file
- > Horizontal interpolation
- > Forcing removed below the tropopause
- > Adapting the code for SW and LW bands

Vertical interpolation

Original



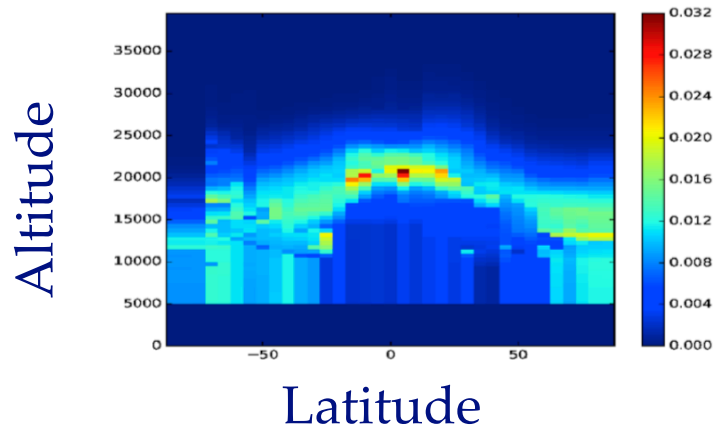
Interpolated



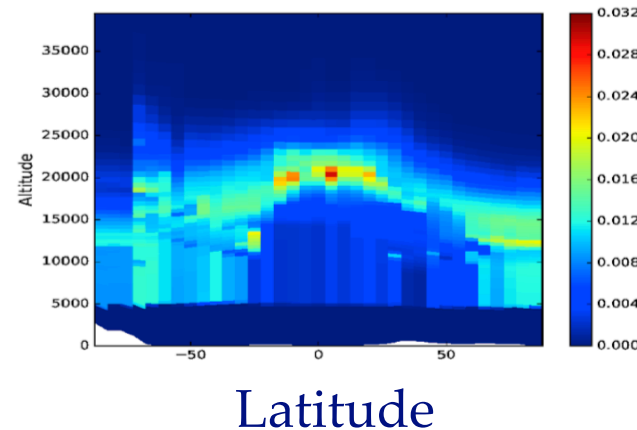
AOT (Qext)
June 1991,
Pinatubo

Vertical interpolation

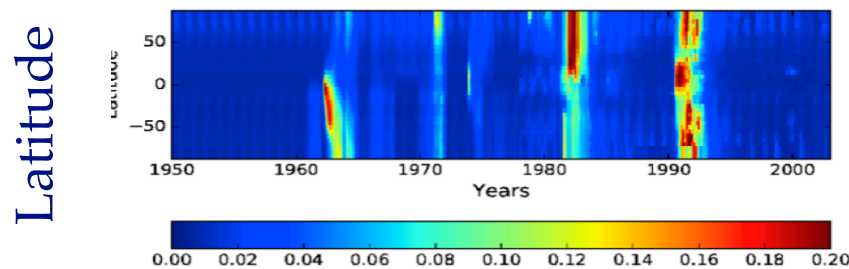
Original



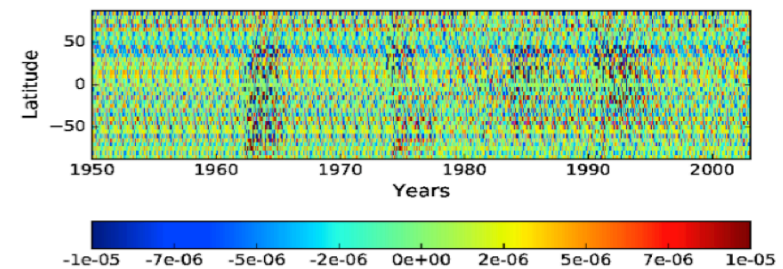
Interpolated



AOT (Qext)
June 1991,
Pinatubo



Total AOD, 1950-2000



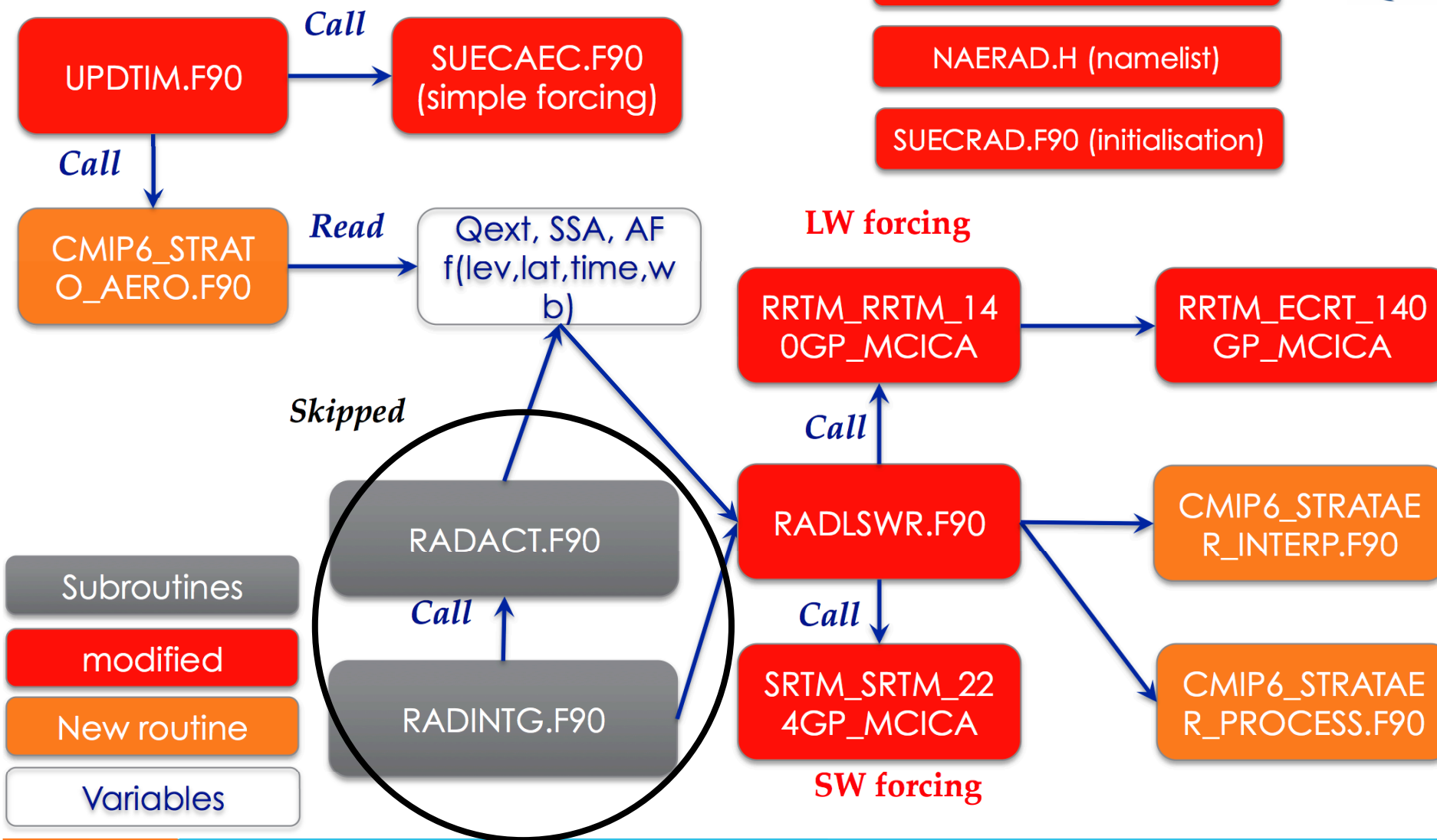
Error after interpolation (%)

=> Monthly files available for 91 levels (soon for 62 and 137)



CMIP6 STRATOSPHERIC AEROSOLS IN IFS

phys_ec/Makefile
YOERAD.F90 (module)
NAERAD.H (namelist)
SUECRAD.F90 (initialisation)



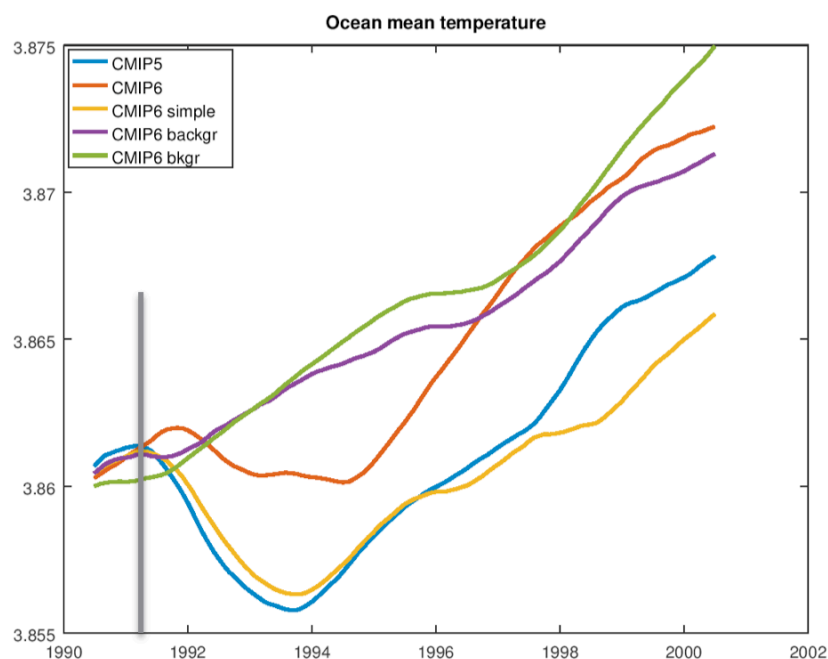


Results and status

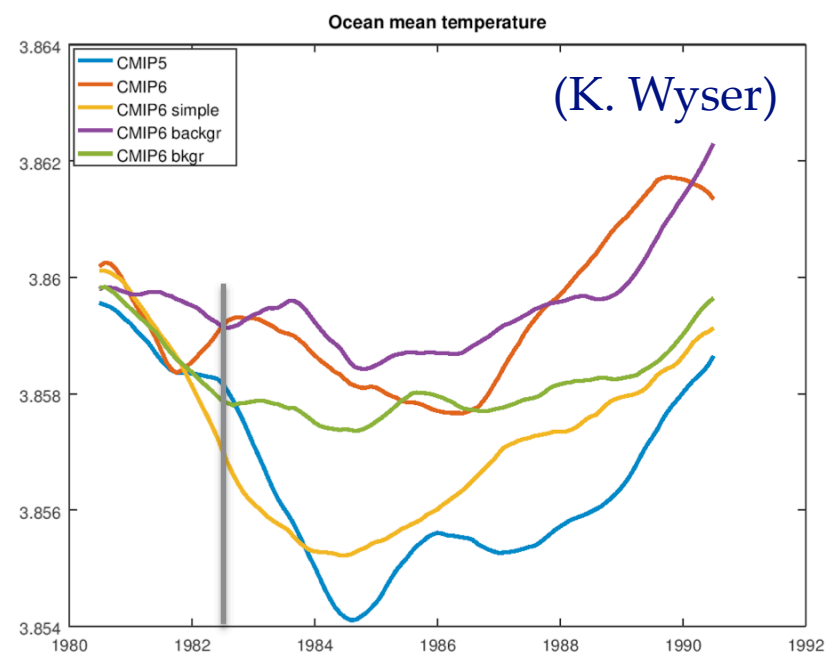


- **Developments implemented in the trunk (“simple” and “full” implementation)**
- **Flags: LCMIP6_STRAT_SIMP, LCMIP6_STRAT_FULL and LBCKGD_STRATAER (to remove eruptions)**
- **“CMIP5” and “CMIP6 simple” : similar forcings**

- **Developments implemented in the trunk (“simple” and “full” implementation)**
- **Flags: LCMIP6_STRAT_SIMP, LCMIP6_STRAT_FULL and LBCKGD_STRATAER (to remove eruptions)**
- **“CMIP5” and “CMIP6 simple” : forcings with a similar magnitude**

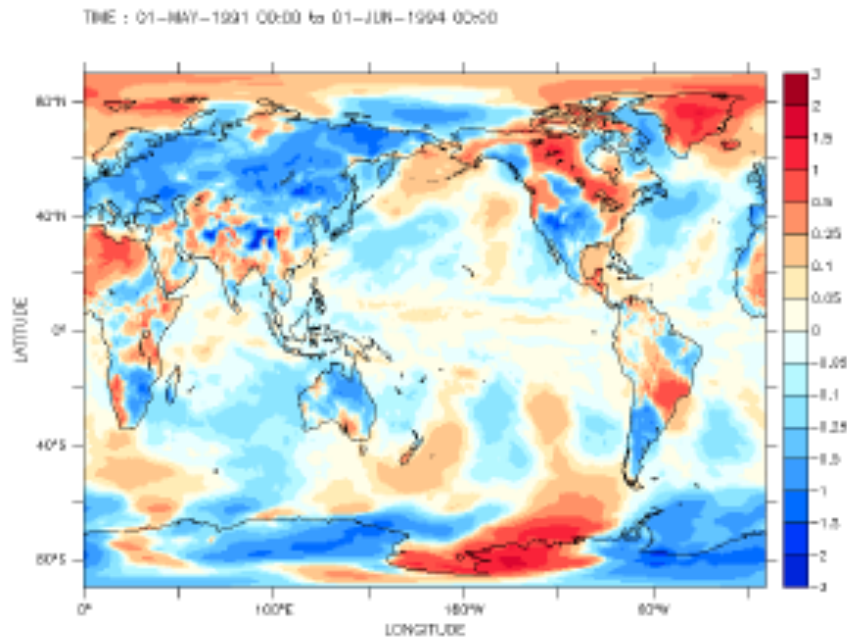


Pinatubo

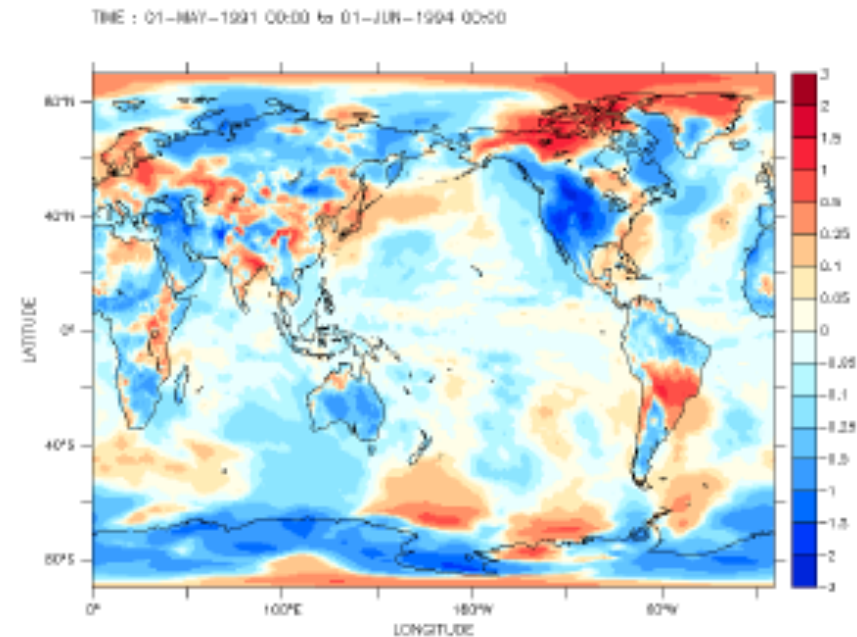


El Chichón

- Impact on T2m slightly smoother in the full versus the simple implementation



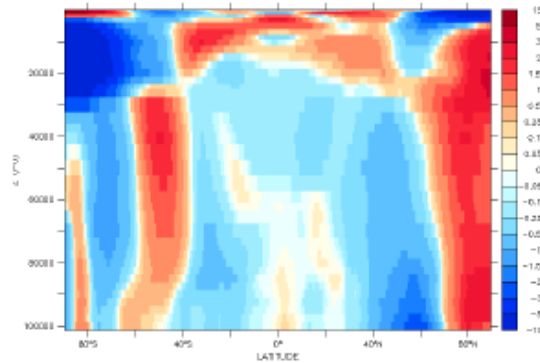
(c) T2M 3Yr ano, full forcing



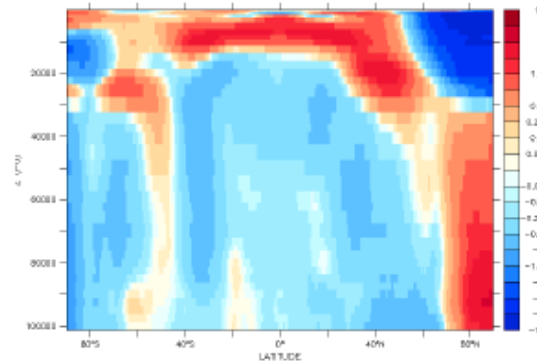
(d) T2M 3Yr ano, simple forcing

Pinatubo eruption (May 1991 – June 1994), IFS-only experiments

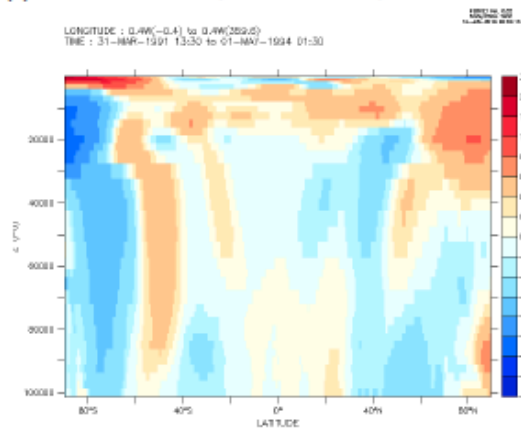
- Full forcing weaker than the simple forcing (troposphere and stratosphere)



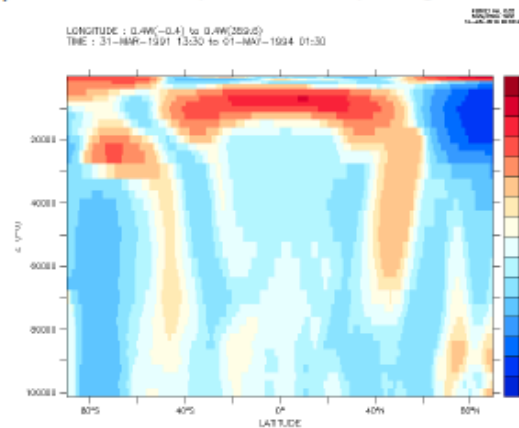
(i) Zonal T ano, 1st winter, full forcing



(j) Zonal T ano, 1st winter, simple forcing



(l) Zonal T ano, 3 Years, full forcing



(m) Zonal T ano, 3 years, simple forcing

Pinatubo eruption, IFS-only experiments

Ongoing tasks



“Simple” scheme

Used in PRIMavera
and CMIP6 runs

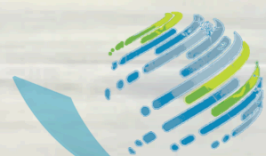
“Full” scheme

Further scientific
validation (**ongoing**)
To be used in CMIP6
runs?

→ EC-Earth: <https://dev.ec-earth.org/issues/232>



Thank you



SPECS

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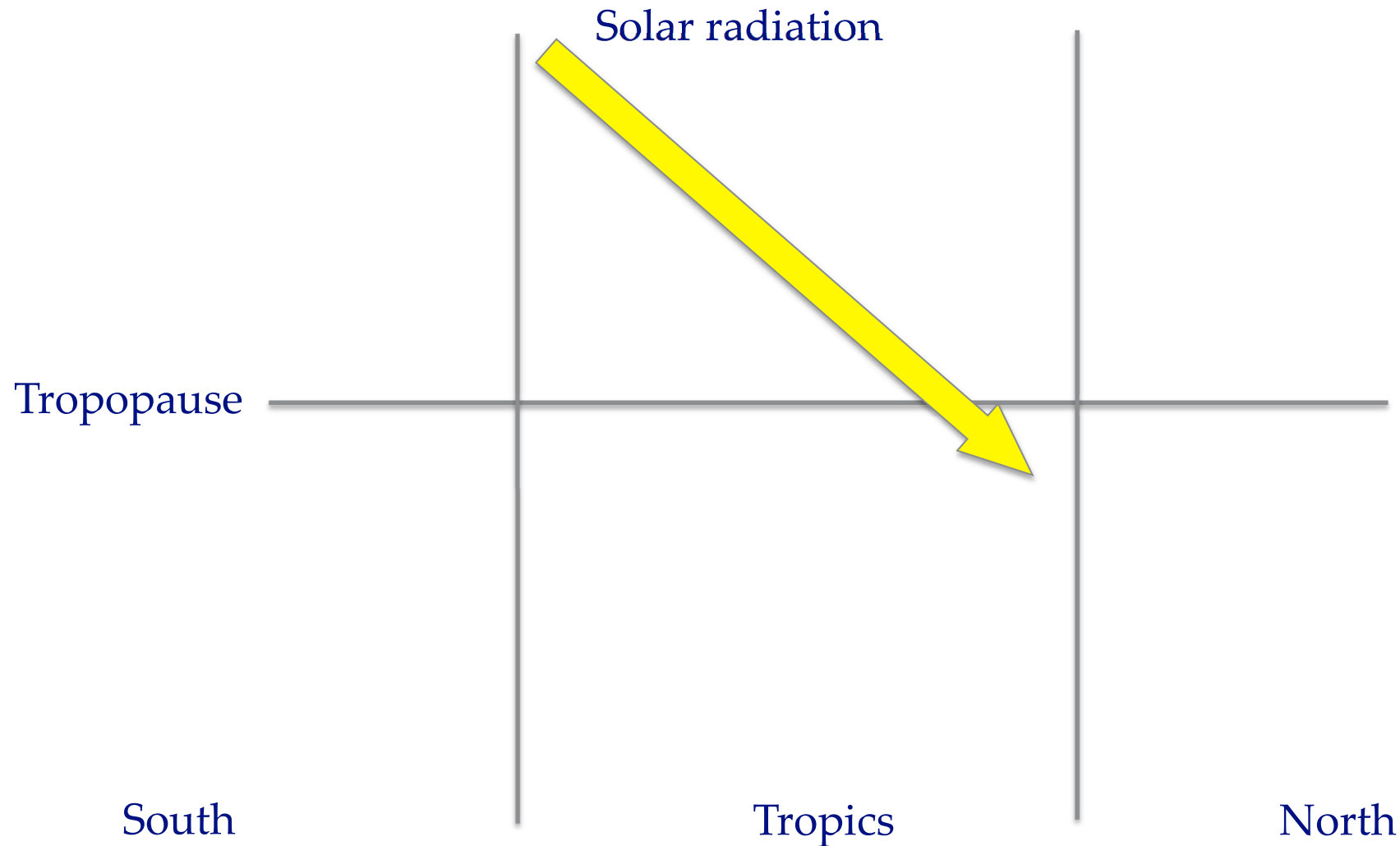
VOLCADEC

Reading, 2018

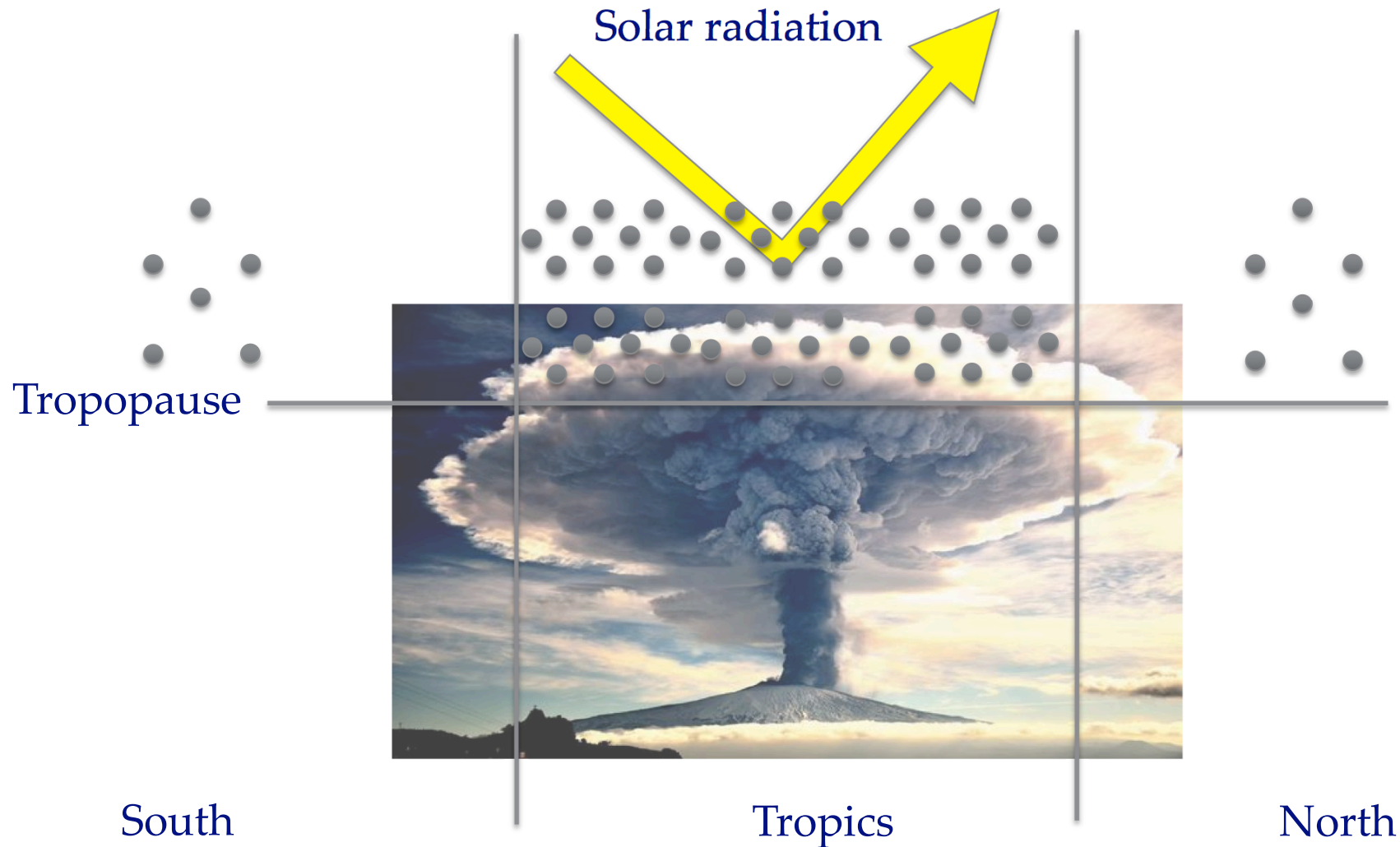
14

Appendix

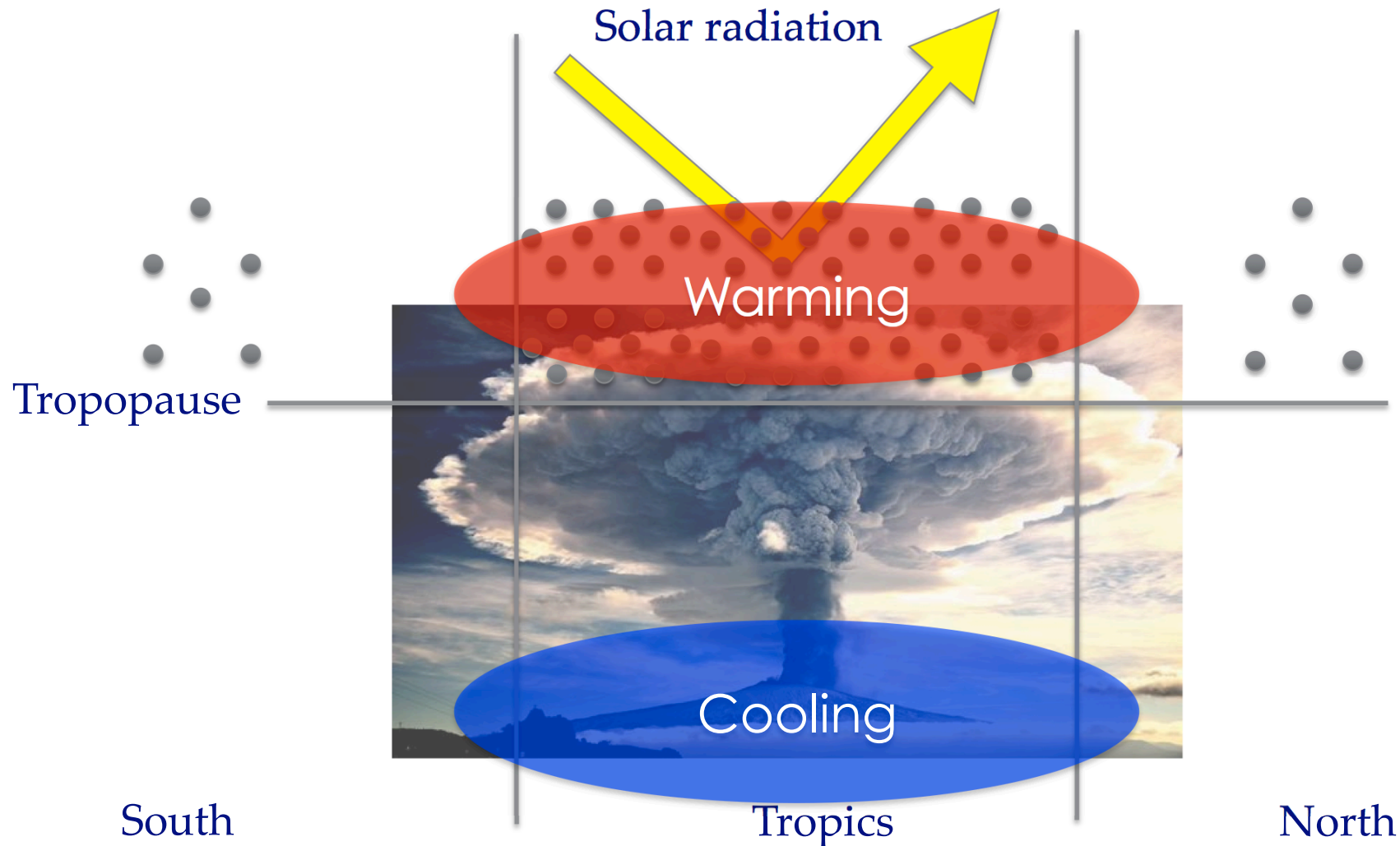
Volcanoes and climate




Volcanoes and climate



Volcanoes and climate



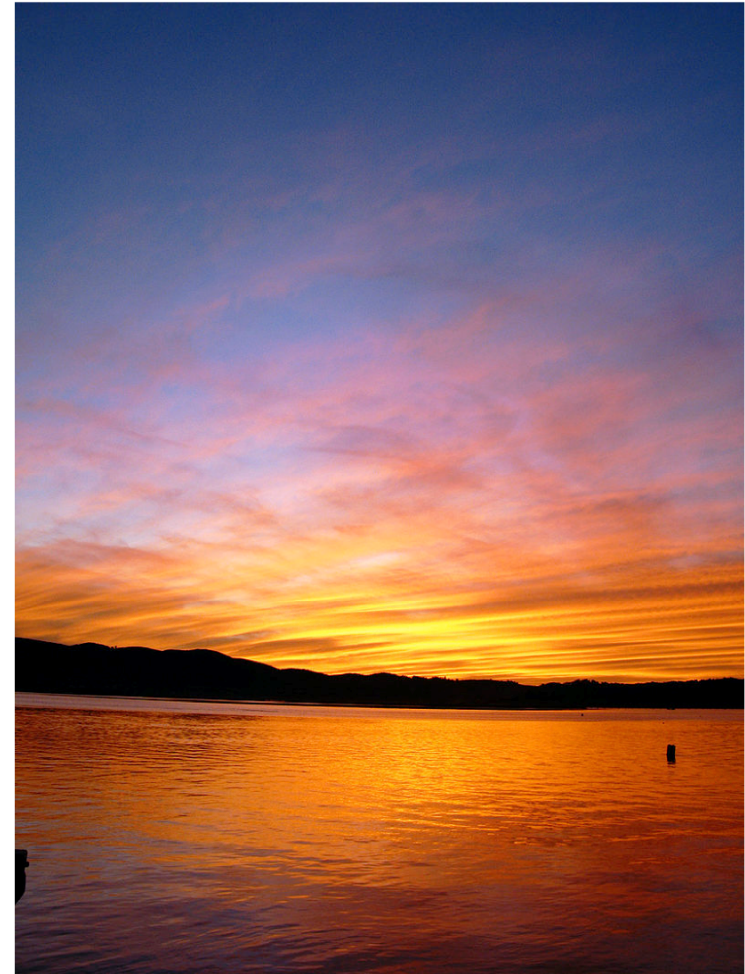
 $\emptyset < \lambda \rightarrow$ Rayleigh theory

 $\emptyset > \lambda \rightarrow$ Optical geometry

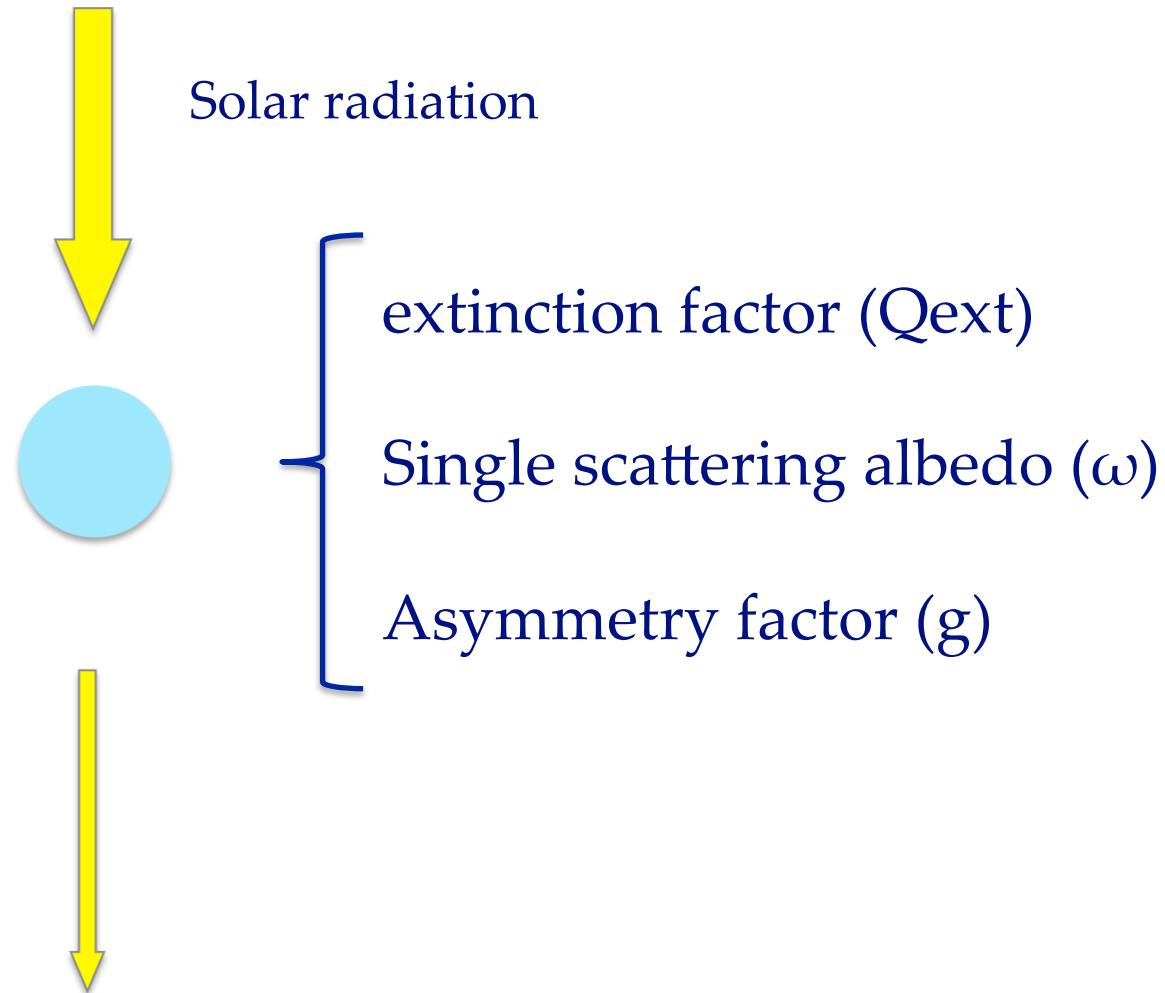
● $\emptyset < \lambda \rightarrow$ Rayleigh theory

● $\emptyset \sim \lambda \rightarrow$ Mie theory

● $\emptyset > \lambda \rightarrow$ Optical geometry



The Mie theory



Tropospheric aerosols: CMIP5 and CMIP6 datasets,
or coupling with TM5

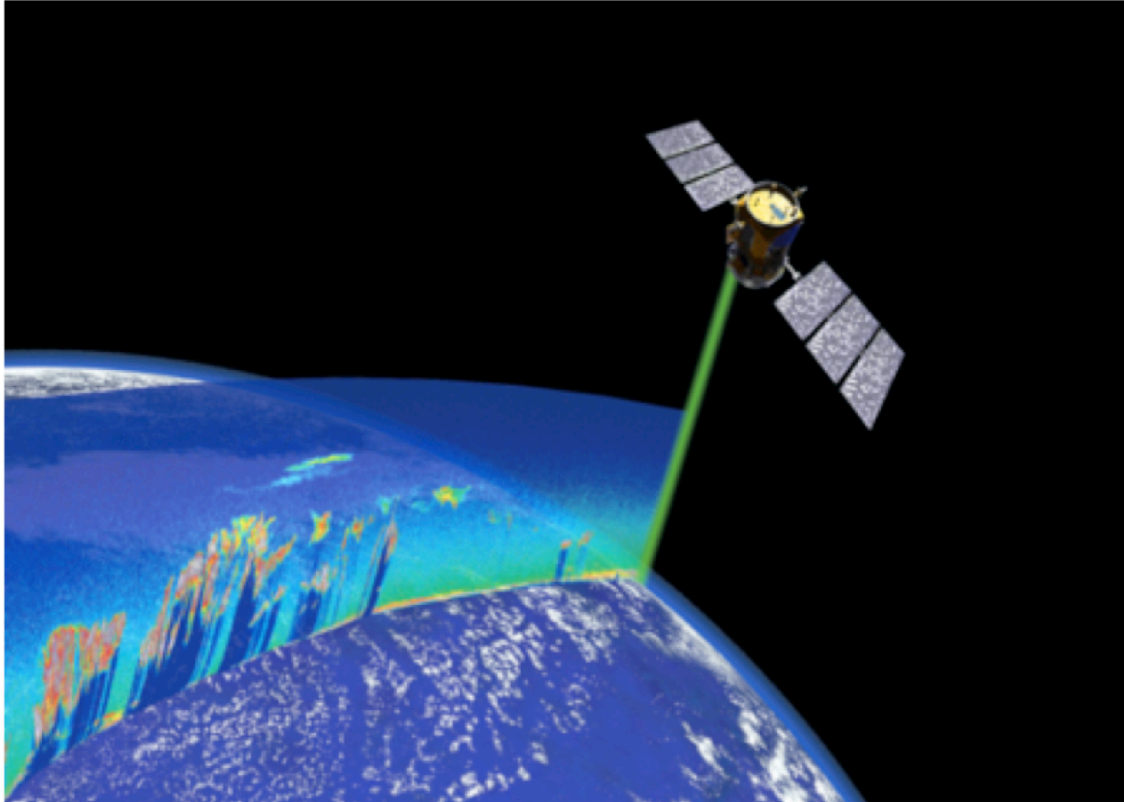
Stratospheric aerosols: CMIP5 (GISS dataset; Sato et al., 1993)
Updated in 2012: <http://www.columbia.edu/~mhs119/StratAer/>

-> $Q_{\text{ext}} = f(\text{latitude, time})$

-> Spectral and vertical distribution computed on-line
(homogeneous and constant distribution)

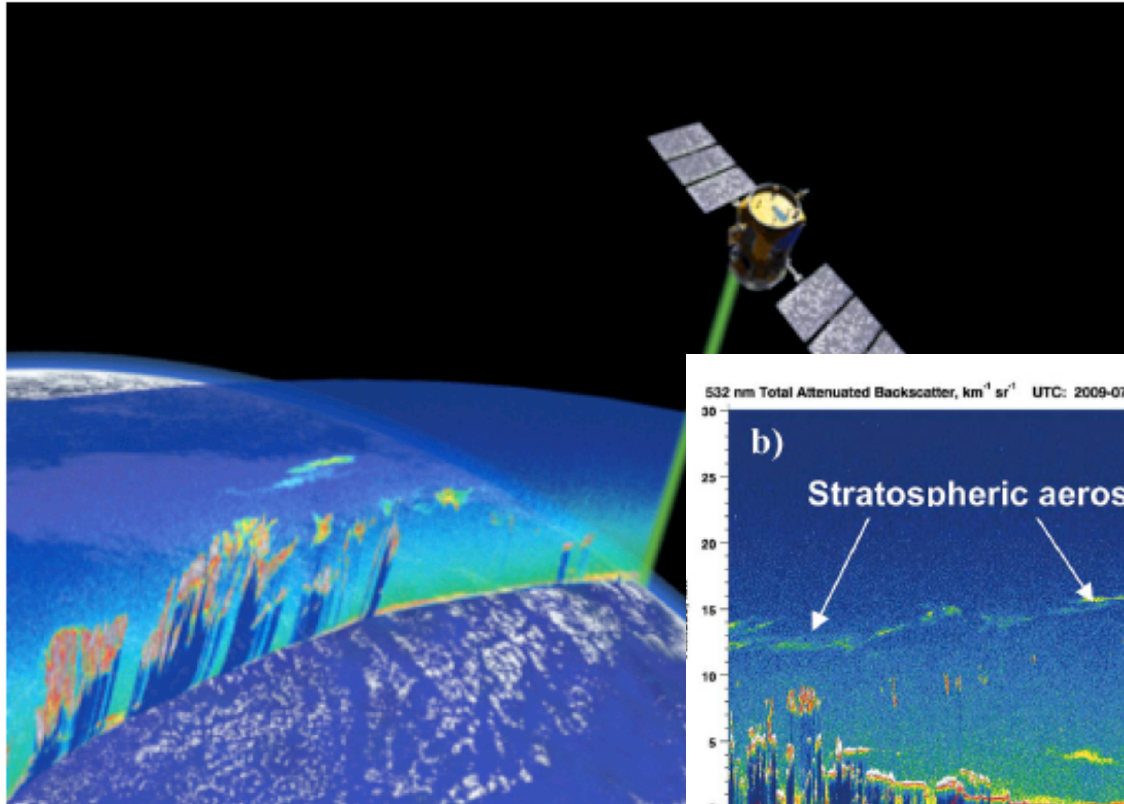
-> ω and g prescribed

Datasets improvements

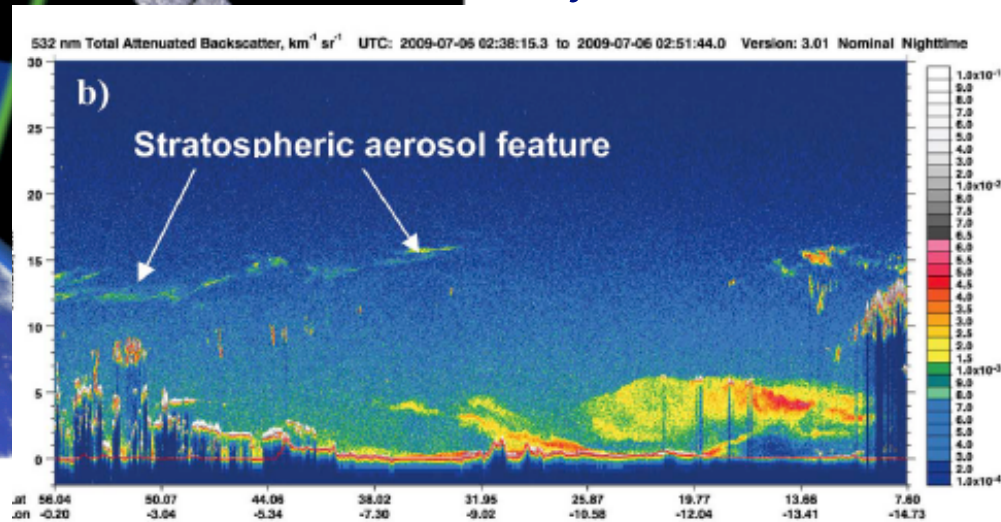


CALIPSO dataset, satellites

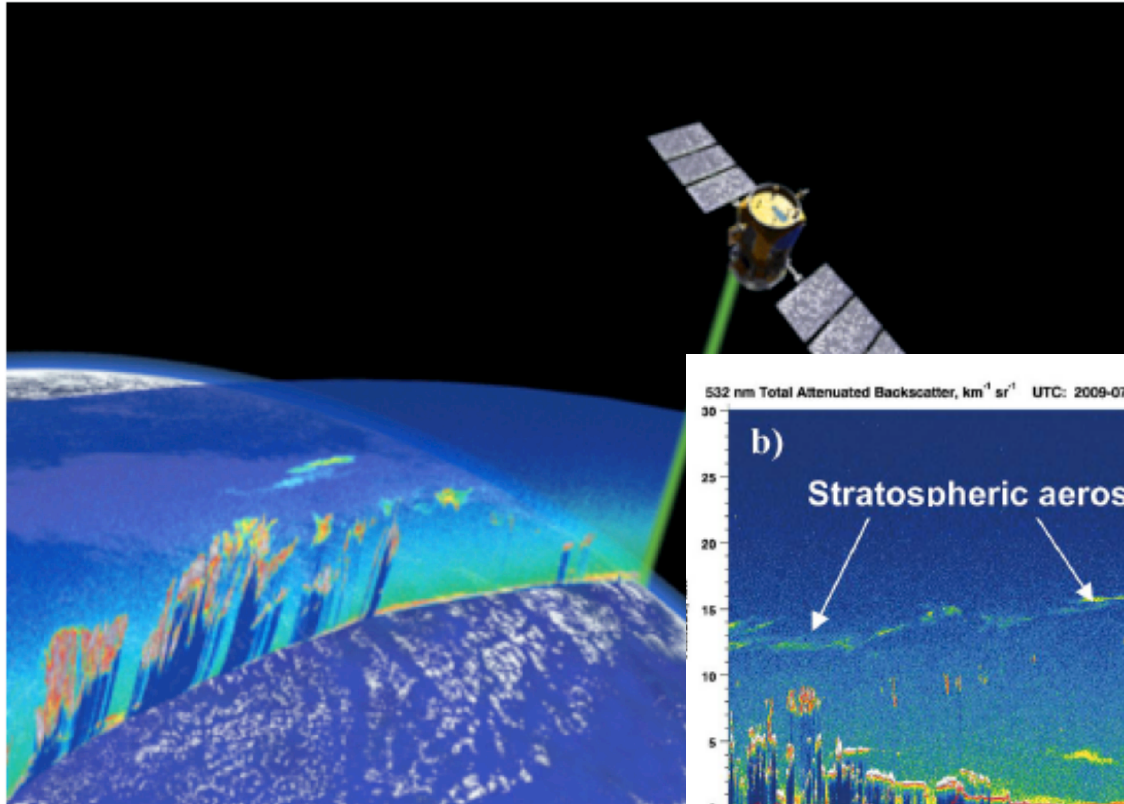
Datasets improvements



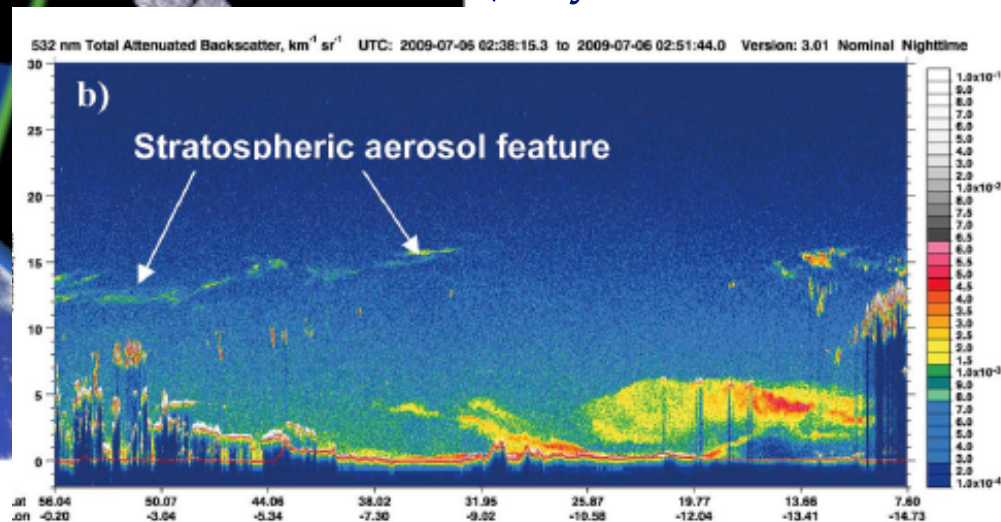
CALIPSO dataset, satellites,
(Haywood and Boucher, 2010)



Datasets improvements



CALIPSO dataset, satellites,
(Haywood and Boucher, 2010)



CMIP6 dataset $\rightarrow Q_{\text{ext}}$, ω and g are $f(\text{lat}, \text{lev}, \lambda, \text{time})$
 Provided for each model, following its spectral resolution (B. Luo)

CMIP5 forcing from CMIP5

CMIP6 full 3-d forcing from CMIP6 (v3.0)

CMIP6 simple simplified forcing from CMIP6 (v3.0)

CMIP6 backgr simplified forcing, only background
(repeating year 1849 from CMIP6 forcing v2.0)

CMIP6 bkgr lbckgd_strataer=TRUE



*Sarychev volcano,
2009, NASA*

→ Old 2D forcing (Lat, Time): GISS climatology
Sato et al., 1993, updated 2012:
<http://www.columbia.edu/~mhs119/StratAer/>

→ New CMIP6 forcing, 4D Forcing (lev, lat, time, wbs)
Provided by Beiping Luo:
ftp://iacftp.ethz.ch/pub_read/luo/CMIP6/EC_EARTH/

→ Issue on the portal: <https://dev.ec-earth.org/issues/232>

→ Git issue:
<https://earth.bsc.es/gitlab/es/auto-ecearth3/issues/92>



*Sarychev volcano,
2009, NASA*